E7.4-10303
CR-136785

WOLF RESEARCH AND DEVELOPMENT CORPORATION

10 August 1973

ERTS 1

Type I Progress Report No. 5
June 1973 - July 1973

---

a. Title. The Interdependence of Lake Ice and Climate in Central North America

b. Proposal Number. 113

c. GSFC ID Number. P506

d. Problem Areas. Analysis of ERTS 1 imagery for the autumn of 1972 proceeded in an orderly fashion and was completed during the reporting period. However, a detailed comparative analysis of ERTS 1 observations with meteorological parameters will delay study of imagery taken during the spring of 1973 by approximately 6-8 weeks. This lag period may have an impact on the quantity of imagery examined at a later point in this investigation.

There has been a delay of nine full months in the reception of back ordered meteorological data from the Canadian government. This circumstance has contributed to the delays cited above.

e. Accomplishments. All ERTS 1 imagery from the test site for the period 15 September 1972 through 09 January 1973 have been examined for the ice condition of major study lakes and position of the lake freeze transition zone. This phase of the investigation was completed during the reporting period, and an intensive comparative analysis of the transition zone with regional meteorology was begun. The results of that analysis will be presented as an unscheduled report, due September 1973.

(E74-10303) THE INTERDEPENDENCE OF LAKE ICE AND CLIMATE IN CENTRAL NORTH AMERICA Progress Report, Jun. - Jul. 1973 (Wolf Research and Development Corp.) 10 p HC $4.00 CSCL 08L G3/13 N74-17092 Unclas 00303

f. Projected Work. During the next bi-monthly reporting period, comparative analysis of data derived from ERTS 1 imagery and independently acquired meteorological data will be completed, and the findings reported. At the same time during the period analysis of imagery taken during the Spring of 1973 will begin.

g. Results. No significant results are available for reporting at this time. However, a description of specific images which display interesting or unusual meteorological phenomena is presented as an addendum to this report.

h. Publications. None

i. Recommendations. None

j. Studing Order Form Changes. None

k. Data Request Forms. Two, dated July 5, 1973 and July 17, 1973.

l. Image Descripter Forms. One, dated July 5, 1973.

MESOSCALE METEOROLOGICAL PHENOMENA OBSERVED BY THE ERTS-1 SATELLITE

During the course of an ERTS-1 investigation to determine the interdependence of lake ice and climate in central North America, a number of interesting meteorological phenomena were detected on various scenes taken by the satellite. Since most of these phenomena were totally unrelated to the objectives of the aforementioned investigation, they have not been documented. Consequently, this report has been written to apprize those interested in mesoscale meteorology of the capabilities of ERTS in this branch of weather science.

The meteorological phenomena to be discussed can be classified into two broad categories relative to their origin: (1) natural, (2) man-made. Table 1 gives a complete listing of types of phenomena observed, their location, date of observation, and ERTS Image Identification Number. The meteorological feature displayed on each image will be described, although actual examples from the imagery will not be included in this brief report. The interested reader is encouraged to acquire cited ERTS-1 imagery from any of the public distributors, such as the EROS Data Center of the United States Geological Survey.

Cumulus Cloud Generation

During autumn the mean temperatures of most moderate-sized water bodies are usually somewhat higher than that of the overlying air. Should the air likewise be unsaturated, the probability of generating convective clouds over the relatively warm water surface is greatly enhanced. Clouds produced in this manner have been frequently observed over larger water

Table 1. Mesoscale Meteorological Occurrences Observed by ERTS-1

Origin	Mesoscale Phenomenon	Geographical Location	Observation Date	ERTS-1 Image ID
Natural	Cumulus Cloud Generation	Wollaston Lake, Saskatchewan	05 NOV 72	1105-17372
		Trout Lake, Ontario	13 NOV 72	1113-16421
		Sand Lake, Ontario	02 DEC 72	1132-16482
		Garrison Dam Reservoir, North Dakota	05 DEC 72	1135-17063
		Fort Peck Reservoir, Montana	09 DEC 72	1139-17292
		Lake Nipigon, Ontario	14 DEC 72	1144-16140
Natural	Snow Squalls	Grand Rapids, Michigan	11 DEC 72	1141-15585
Man-Made	Smoke Plumes	Chicago-Gary Metropolitan Area	24 NOV 72	1124-16050
		Saskatchewan, North Dakota Border	07 DEC 72	1137-17173
Man-Made	Jet Contrails	Rockford, Illinois	14 DEC 72	1144-16160 1144-16163
Man-Made	Smog	Minneapolis, Minn.	18 SEP 72	1057-16320

bodies, such as the Great Lakes, and their influence on local downwind climatology is well known. For example, in winter the leeward sides of the Great Lakes are characterized by narrow, but intensive, snow belts which result when moisture-laden clouds generated or intensified over the lakes reach the colder land surface and lose their water carrying ability.

Active cloud generation over smaller lakes has been observed in various ERTS scenes. These lakes are identified in Table 1, and details of each observation are presented below.

1. Wollaston Lake. Although at the time Wollaston Lake was approximately 90 percent ice covered, streams of cumulus puffs emanating from the open water surface are discernible for about 40 km in a north to south direction. Weather data from stations in the vicinty confirm the direction of flow.

   The observed clouded area can be divided into two phenomenological regions: (1) a 'cloud generation' region where individual cloud streams or plumes are detectable, each exhibiting a cone-shaped dispersion pattern; and (2) a 'cloud collection' region where all plumes coalesce into large, somewhat irregular clouds or banks of clouds before dissipating. The two regions were visible in all ERTS scenes in which cloud generation appeared. Typically, region (1) occurred over the open water portions of the lakes, while region (2) lay over the land surface and/or frozen portions of the lakes.

2. Trout Lake. Numerous small rills of cumulus puffs can be observed originating from the unfrozen surface of Trout Lake and several other smaller lakes in the vicinity. The clouds have a visible extent of slightly over 15 km, oriented in a northwest to southeast direction. Weather patterns for the same date show a strong high pressure system located immediately west of the lake and this system was apparently responsible for inducing cloud generation.

3. Sand Lake. As in the previous cases, this lake is mostly frozen, all lakes in the immediate vicinity are completely frozen, and streams of cumulus clouds are being produced from the open water surface. The lack of nearby clouds enables the plume to be traced in an east- outheast direction nearly 20 km. The total amount of open water involved in generating the clouds is estimated to be 12 km^2. Minimum air temperatures for the day in the region averaged about -18°F, and the dew point-temperature difference was 6°F. The extremely cold, dry air was obviously responsible for the local clouding conditions.

4. Garrison Dam Reservoir. The scene for this reservoir (also called Lake Sakakawea) represents the best example of cloud generation from a small-to-moderate water surface area of any observed thus far. The total length of the clouded region is estimated at about 30 km, the direction of flow running northwest to southeast. A majority of the reservoir's southern shore is clouded over for a distance of about 10 km inland.

5. Fort Peck Reservoir. Nearby stratus clouds obscure the extent of the plume from this impoundment. However, cumulus streams are readily apparent against the dark water surface background.

6. Lake Nipigon. A well-developed cumulus cloud system is visible over the small open portion of Lake Nipigon which appears on this image. Since the remainder of the image is essentially cloud free, cloud generation from the lake surface probably accounts for the cumulus system. On December 4, the dew point-temperature difference at Lake Nipigon was 13°F, a condition highly conducive to drawing moisture from the lake.

Snow Squalls

Although snow showers are common to the test site, they are not easily detectable due to multiple layers of clouds which often hide this low altitude feature of winter meteorology. One example of snow squalls observed by ERTS is cited below.

1. Grand Rapids. A lake effect snow storm can be seen in progress along the eastern shore of Lake Michigan. The cities of Grand Rapids and Kalamazoo mark the easternmost penetration of the storm. Battle Creek, just 25 km due east of Kalamazoo is free of any cloud cover. Using the ERTS scene as a basis, we can postulate that the storm originated from cumulus clouds generated over Lake Michigan which penetrated inland and accumulated against the topographic barrier of a north-south trending line of low hills located about 50 km from the lake shore. The clouds spilled through gaps in the barrier, notably at Grand Rapids, carrying the storm further inland at this point. Weather data from the region support this interpretation.

Smoke Plumes

Given the dissipative capacity of the atmosphere, there seems little probability that smoke plumes from point sources such as industrial stacks would be visible on ERTS imagery. However, this is indeed the case as demonstrated by the following examples.

1. Chicago-Gary Metropolitan Area.

This image displays an excellent example of man's activities inadvertently affecting local weather. The scene contains the southern tip of Lake Michigan and parts of Illinois, Indiana, and Michigan. Scattered areas of recent snow shower activity are readily evident in the scene whose land surface is completely cloud free. Lake Michigan, on the other hand, is partially covered by streams of cumulus clouds indicating that cloud generation is occurring over the lake. The direction of flow, as evidenced by the orientation of cloud puffs, is southwest to northeast.

Nothing extraordinary is apparent from the above description. However, tracing the most prominent cloud streams to their southwest extreme reveals that they merge with visible smoke plumes emanating from the Chicago-Gary industrial complex. At least five major smoke plumes can be discriminated along a 30 km segment of the lake shoreline. Man-made smoke plumes are not only distinguishable on ERTS imagery, but they can also play an apparent role in cloud generation. [Similar conclusions were reached by Prof. Walter A. Lyons (University of Wisconsin) in a paper presented at the 1973 Great Lakes Research Conference (Huron, Ohio).]

2. Saskatchewan-North Dakota Border.

Surprisingly, snow cover provides an excellent background upon which to view two well-defined smoke plumes from mining operations in the vicinity of Estevan, Saskatchewan. The larger of the plumes is traceable nearly 15 km in a northwest to southeast direction.

Jet Contrails

High altitude jet exhaust may disperse extremely slowly in the uniform, relatively less turbulent upper atmosphere. As in the case of the smoke plumes, however, the probability of viewing such contrails seems low. Two consecutive ERTS scenes contain a number of extremely long thin cloud-like structures which might be interpreted as jet contrails.

1. Rockford. The ERTS scenes referred to in Table 1 cover a swath which extends approximately from Madison, Wisconsin to Davenport, Iowa. Thin veils of cirrus clouds occur sporadically, but no opaque clouds are evident anywhere along the swath. The snow-covered ground surface reflects shadows of the high altitude clouds, and these shadows stand out clearly on the imagery. Of particular interest are 8-10 long, linear clouds oriented northeast-southwest across the swath. (Two low altitude smoke plumes visible on one of the scenes (1144-16163) confirm the predominant flow direction as northeast to southwest). Some of the structures exhibit lengths of about 90 km and apparent widths of less than 2 km. These unusual clouds are

probably the product of some uncommon high altitude flow processes; however, they may represent the diffused remnants of jet traffic from major midwestern cities.

Smog

Gascons industrial effluents, automobile exhaust emissions, and intense sunlight can combine to proudce photochemical smog over large urban areas. If one were to postulate appropriate weather conditions, such smog may attain sufficient density as to become visible from satellite altitudes. The appropriate weather conditions may have occurred over Minneapolis-St. Paul, Minnesota on September 18, 1972.

1. Minneapolis. The ERTS scene referenced in Table 1 includes a considerable portion of southern Minnesota, as well as the metropolitan area of Minneapolis-St. Paul. The extreme eastern edge of the scene contains highly reflective, solid banks of cumulus clouds. The only other sky cover in this scene is located exactly over the urban portion of Minneapolis-St. Paul. These clouds are partly transparent and diffuse; they bear no resemblance to the cumulus cloud system roughly 10 km to the east. Assuming that the position of the diffuse cloud system is not merely coincidence, the obvious conclusion is that the urban area is the source of the clouding. An examination of weather records should reveal if the sky cover was actually smog.

A. Jelacic
ERTS-1 Principal Investigator
August, 1973